Inter-Departmental Communication

DATE: November 12, 1998

TO: Mayor Emanuel Cleaver II and Members of the City Council

FROM: Mark Funkhouser, City Auditor

SUBJECT: Review of the City's Flood Response

On Friday, October 16, 1998, Mayor Emanuel Cleaver II requested that the City Auditor's Office conduct an inquiry into the city's response to the October 4th flood. Recent newspaper articles reported that the Brush Creek flood warning system, known as Enhanced ALERT (Automated Local Evaluation in Real Time), failed during the flash flood. The system, intended to provide information to help city personnel plan for and respond effectively to severe weather conditions,[1] was inactive during the flood. This inquiry is intended to answer three questions:

1. What caused the inactivity of the flood warning system?

2. How did the inactivity of the system impact the responsiveness of emergency providers?

3. What should be done to improve city responsiveness in future flash flooding situations?

CONCLUSIONS

The decoder, a device that converts radio signals into useable data, was not plugged in on October 4th, preventing the city's base station from receiving information from flood gauges. The unplugged decoder however, was only one element of a system that has never been fully operational. Even if the decoder had been operating, all of the stream level and most of the precipitation gauges installed along Brush Creek were not working. The city did not have a comprehensive plan for responding to flood warnings that included routine identification, monitoring, and blocking of flooded streets and bridges. In addition, there is no educational program in place. Such programs are designed to reduce the risk of accidents by explaining to the public the risks of traveling during flood emergencies and instructing them not to attempt to drive through standing or flowing water on roadways. In the absence of the other components of

[1] U.S. Army Corps of Engineers, *Brush Creek Operation and Maintenance Manual*, p. 9-1.

an effective flood warning system, the fact the decoder was unplugged likely had little or no impact on the city's overall flood response.

To improve city responsiveness in future flash flooding situations, we recommend the city manager oversee the development of a comprehensive plan for flash flooding. Responsibilities of the city and the National Weather Service for the warning system should be written and accepted by the City Council by ordinance. In addition, steps should be taken to ensure personnel responsible for the warning system are able to perform the work, and Emergency Preparedness should be moved to City Manager's Office. Finally, a public education effort should provide ongoing information on flooding, its dangers, and the precautions citizens should take during flash flood watches and warnings.

WORK PERFORMED

We interviewed staff in the city's Police, Fire, Public Works, and Water Services departments; the National Weather Service (NWS); experts in emergency preparedness systems; and the U.S. Army Corps of Engineers (COE). We also reviewed records from the city's dispatch systems, readouts from the city's flood monitoring system, information from the NWS and the COE, and written emergency response procedures from the Fire Department. Audit staff also attended the city manager's October 22nd meeting on the city's flood response, the October 29th business session (at which the city manager reported on the earlier meeting), and the November 2nd training session on emergency response. Finally, audit staff observed one of the city's flood monitors on Brush Creek and the computer system that receives the monitors' information, located in the Fire Department dispatch office.

BACKGROUND

On October 4, 1998, a severe rainstorm occurred in the Kansas City area. The National Weather Service issued a flash flood warning at 2:58 p.m. for all of Jackson County, Missouri. The rain intensified in the early evening and additional warnings for the county were issued at 7:13 and 10:57 p.m. In the one-hour period between 7:00 and 8:00 p.m., between 2.29 and 2.95 inches of rain were received at different areas surrounding Brush Creek.

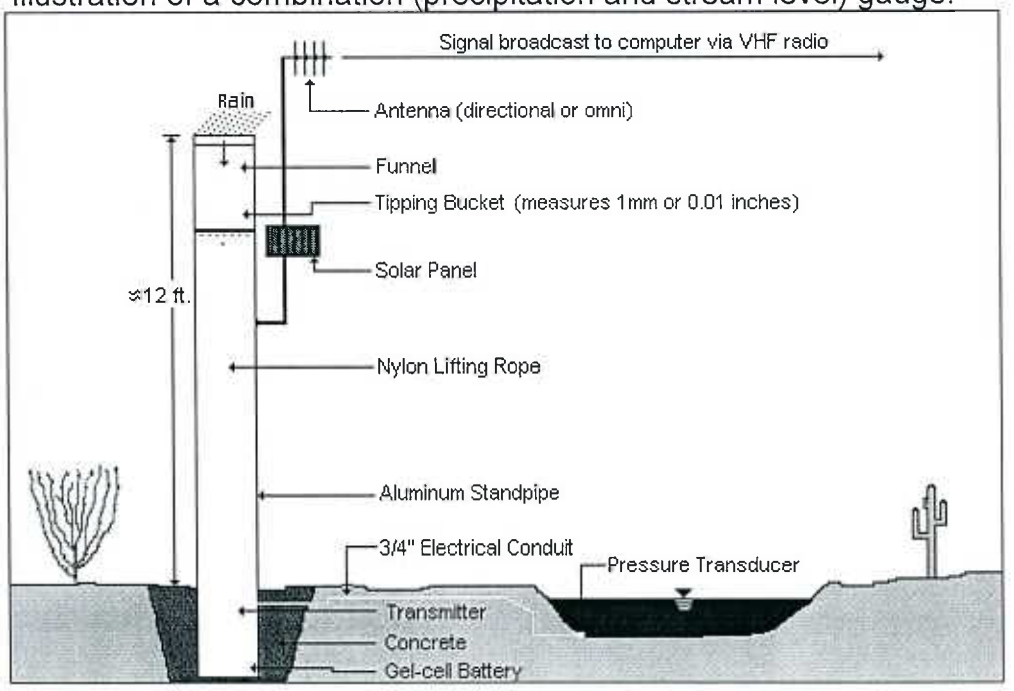
Floods are a relatively common natural disaster resulting in great economic loss and loss of life. According to a Department of Commerce preparedness guide, several factors contribute to flash flooding. Two key elements are the rate of rainfall and how long the rain lasts. Topography, soil conditions, and ground cover also play important roles. Flash floods occur within minutes and can roll boulders, tear out trees, and destroy buildings and bridges. Rapidly

rising water can reach heights of 30 feet or more. There is not always a warning that sudden floods are coming. Most flood deaths occur in flash floods.[2]

Flood Warning Gauges

As part of the Brush Creek flood control project, the U.S. Army Corp of Engineers proposed installing six precipitation and four stream gauges in Missouri and Kansas. The precipitation gauges consist of the standard tipping bucket design with an accuracy to every one millimeter of precipitation. Stream gauges, using pressure transducers, report each 0.01 foot of changes in river levels. As the river level changes, a corresponding pressure change results in the stream level reading. The gauges are battery powered with solar panels.[3] (See illustration.) Precipitation, stream level, and combination gauges were used in the Brush Creek project. Gauges were also installed on the Blue River and Turkey Creek. The city monitors a total of five precipitation, one stream level, and 13 combination gauges, located in Missouri and Kansas. (See attached map.)

Illustration of a combination (precipitation and stream level) gauge.



Source: Maricopa, Arizona Flood Control District Internet page, (http://156.42.96.70/alert/whatis.htm), October 27, 1998.

---

[2] U.S. Department of Commerce, *flash floods and floods. . . the Awesome Power!*, July 1992, p. 1.

[3] U.S. Army Corps of Engineers, *General Design Memorandum, Brush Creek Enhanced Channel Modifications*, May 1990, p. B-3.

The gauges send data to a receiver and repeater at City Hall. Base stations are located at fire dispatch and the National Weather Service. A decoder converts the radio signals into useable data for the computer software. The computer can be programmed to set off alarms when various conditions – such as certain stream levels – are reached.

Responding to Emergencies

According to the Fire Department's *Emergency Action Plan: Flooding on the Brush Creek*:

> If there are any flash flood watches or warnings, flooding watches or warnings or periods of heavy rainfall, the ALERT system monitoring conditions on Brush Creek will be closely attended.

Several non-city and city offices are also involved in responding to a flood emergency. The National Weather Service is legally mandated to issue current and forecasted severe weather information, including flood and flash flood warnings. Once flooding has been reported, the city's Parks and Recreation, Public Works, and Water Services departments block streets.

ANALYSIS

Our inquiry into the events of October 4th disclosed conditions that affected the city's response to flood emergencies. The decoder that converts radio signals from the flood gauges was not plugged in, preventing readings from the gauges from reaching the city's computer system. Had the decoder been functioning, information from the working gauges would have probably provided only 10 to 20 minutes of additional response time. The city's plan for handling such emergencies would not have effectively utilized this minimal amount of time. Responsibility for responding to flood emergencies is fragmented among departments, and there is no comprehensive plan for blocking streets. The city has not developed a public education program on flash floods, to help residents understand the need to limit transportation and not drive through standing water.

Data Was Not Recorded Because the Decoder Was Unplugged

The Fire Department's emergency preparedness coordinator informed us that the decoder, which converts radio signals from the city's flood control monitors, was not plugged in on the day of the flood, thus preventing the conversion of data from the flood control gauges into useable data for the city's base station.

Although they did not discover the decoder was unplugged until mid-October, city staff were already investigating a problem with the monitoring system before the October 4th flood.

On September 9, 1998, the National Weather Service (NWS) provided a list of gauges that were not working to city staff. Later that month, city staff met to discuss maintenance problems.

In mid-October, the emergency preparedness coordinator noticed that the decoder, which translates signals from the flood gauges, was not plugged into the wall socket. An AM/FM radio had been plugged in instead. Once plugged back in, the base station once again began receiving information from the city's functioning flood gauges.

Unplugged Decoder Had Little Impact on City Responsiveness

The decoder is only one element of the city's flood monitoring system. Most of the warning gauges were not working. The city did not have a comprehensive plan for responding to flood warnings. In addition, there was no education program designed to instruct the public about the dangers of flash floods and the proper precautions to take. Without the other components of an effective flood warning system, the unplugged decoder likely had little or no impact on the city's overall flood response.

System was never completed. The flood monitoring system is part of the Brush Creek flood control project constructed by the U.S. Army Corps of Engineers (COE). The project, including the warning system, was authorized in 1986. Federal regulations specify that flood control projects built by the COE are operated and maintained by local agencies.[4] For the Brush Creek project, the city is the local agency responsible for operations and maintenance.

According to the COE's 1981 feasibility report, operating the warning devices requires that they are installed properly and checked frequently.[5] At a 1992 meeting with city staff, representatives of the COE recommended daily checks of each device using the base station, and changing the devices' batteries every six months.

Since the warning gauges were installed, there have been numerous reports of problems with their operation. We reviewed minutes of the Blue River Task Team meetings from March 1995 through September 1998. The Blue River Task Team includes representatives of the city, the NWS, the COE, the U.S. Geological Survey, and other groups interested in or affected by the Blue River and Brush Creek flood control projects. The minutes noted frequent reports of problems with the Brush Creek warning devices, including difficulty receiving the radio signals, hardware problems with the city's base station, and problems maintaining and tracking maintenance of the gauges.

---

[4] 9 F.R. 10203, August 22, 1944. *Maintenance and Control of Flood Control Works.*

[5] U.S. Army Corps of Engineers, *Feasibility Report and Environmental Impact Statement: Brush Creek & Tributaries*, September 1981, p. 43.

According to the NWS, during the October 4th flood, only five of the ten precipitation gauges were working, while none of the six stream level gauges were functioning. The NWS data shows these gauges recorded about four inches of rain on October 4th, from about noon to 8:00 p.m. Staff at the NWS report that this amount of rain could cause small, less severe flooding if the soil were dryer. Given the saturation of the soil on October 4th, this amount of rain will cause flash flooding.

In July 1998, the NWS presented a draft Memorandum of Understanding (MOU) between the NWS and the city, defining a mutual cooperative program for the development and operation of a cooperative flood warning system. City staff have reviewed and made comments on the draft. However, neither the city nor the National Weather Service have signed the memorandum.

We reviewed the draft MOU received from the NWS and the current revisions prepared by city staff. The revised MOU designates Water Services as responsible for maintaining the warning gauges (including all the gauges monitored by the city), transmission equipment, and the base stations used by both the city and the NWS. In addition, Water Services would monitor the system and notify the NWS of system malfunctions. The Fire Department would be responsible for development and operation of an emergency response plan. The MOU is still being negotiated.

Fire Department dispatch staff have also had difficulties with the base computer. We were told that the alarm settings on the city's base computer are not correctly set and there have been frequent false alarms. Initially, the Fire Department dispatchers reported alarms to the emergency preparedness coordinator. The frequent false alarms resulted in fire dispatch staff feeling the alarms were meaningless. In addition, staff in fire dispatch, where the computer is located, were not trained to interpret the readings.

Even before the October 4th flood, efforts were underway to address problems with the system. Task Team minutes of the September 9, 1998 meeting indicated that the NWS and COE would be reviewing studies to identify the flood threat and flood stages. After completing this work, meetings would be held with city staff to finalize flood stages for Brush Creek.

No comprehensive emergency plan exists. Even with properly functioning equipment and accurate data interpretation, the lack of a comprehensive plan for handling flood emergencies would have reduced the effectiveness of the city's response.

According to the COE's *General Design Memorandum* for the flood control project:

> A flood warning system is composed of 1) the hardware and software to collect, send, and analyze flood data, and 2) an implementation plan which is activated by local officials upon notification of a flood warning. Both elements are essential for the emergency flood warning system to be operational.[6]

The memorandum further states:

> An implementation plan is required for the Brush Creek emergency flood warning system to be operational. This plan will consist of a detailed breakdown of responsibilities for the city, the National Weather Service, and the Corps of Engineers. The plan will outline all procedures to be instituted in the event a flood warning is issued. For example, such a plan would include procedures to notify the general public of an impending flood and appropriate road and bridge closures would be discussed and the necessary city personnel assigned these duties. The development of the implementation plan is the responsibility of the City of Kansas City, Missouri.[7]

The COE feasibility report states that:

> Brush Creek can rise from low flow to flood stage in 30 to 60 minutes. . . .[8] Even sophisticated warning devices would not greatly increase warning time because of the very rapid rise of floodwaters. However, any increase in warning time could save lives.[9]

The COE concludes that saving lives is possible by the provision of 10 to 20 minutes of warning time before flood stages, which inundate streets and bridges adjacent and over Brush Creek, are reached. The plan would require that city personnel act quickly to erect necessary barricades and assist in evacuation of persons in danger.[10]

---

[6] *General Design Memorandum, Brush Creek Enhanced Channel Modifications,* p. B-1.

[7] *General Design Memorandum, Brush Creek Enhanced Channel Modifications*, p. B-4.

[8] *Feasibility Report and Environmental Impact Statement: Brush Creek & Tributaries*, p. 12.

[9] *Feasibility Report and Environmental Impact Statement: Brush Creek & Tributaries*, p. 16.

[10] *Feasibility Report and Environmental Impact Statement: Brush Creek & Tributaries*, p. 42.

Administrative Regulation 1-6, effective on April 1, 1997, details the administrative procedures for flood stage warnings. The policy specifies that the director of Water Services has the authority and responsibility for alerting the City Manager's Office and various city departments of potentially dangerous flood stages and for publishing detailed procedures for notifying officials of potentially dangerous flood stages. These procedures are to be annually reviewed and approved by the city manager. The Administrative Regulation supersedes the prior version, effective on March 29, 1974, which placed responsibility for notification and plan development in the hands of the Public Works director.

Plan lacks detailed procedures to block streets. City staff developed an emergency action plan for flooding on Brush Creek, and a simulated exercise, planned by the emergency preparedness coordinator, was conducted in April 1995. The plan identified sources of information on flash flood watches or warnings issued by the NWS, including the Weather Channel and Weather radio. Once watches or warnings are issued, and during periods of heavy rainfall, the ALERT system should be closely attended. If the ALERT monitors indicate flooding is imminent on Brush Creek, several Fire Department staff should be contacted, the Emergency Operations Center should be activated, and the mayor, city manager, and Police and Public Works departments should be contacted. Should a flood situation develop, police and fire apparatus were to cruise the affected areas, issuing the following message over their loudspeakers:

> Brush Creek is in danger of flooding. We advise you to prepare to evacuate. Tune in your radio. Brush Creek is in danger of flooding.

The emergency plan does not include specific detailed procedures for blocking streets. Flash floods occur within minutes. Waiting for Police or Fire officials to determine that a road or bridge has already flooded wastes time and increases the possibility of citizens becoming trapped on flooded roadways. To take advantage of 10 to 20 minutes of warning time, the city needs a plan that can be put into action quickly, for barricading streets and bridges and evacuating residents. Accomplishing this requires more than a single city department because in severe weather, flooding is likely to occur throughout the city.

Emergency Preparedness Program should be higher in city government organization. According to the Fire Chief, one of the problems with the city's emergency preparedness function is its location in city government. In July 1989, the city's Emergency Preparedness Program was moved from the Administrative Department, overseen by the City Manager's Office, to the Fire Department. The chief suggested that Emergency Preparedness should be returned to the City Manager's Office, where its higher status and visibility in city government could increase its effectiveness and credibility.

Fire and Police report that the calls received that night exceeded the personnel and equipment available. Parks and Recreation, Public Works, and Water Services staff report they routinely assist in blocking streets, but it appears these efforts are only loosely coordinated. During the October 4th flood, 56 barricades were erected at locations throughout the city. Seven of these locations had flood gates. All but one of the gated locations are found in the extreme northern part of Kansas City. Fire staff reportedly prepared a list of high water locations prior to October 4th, based on calls received in the past few years. The list identifies 138 locations.

We agree that the City Manager's Office is the best position to develop a comprehensive plan for the city's flood response effort. Just as several departments are involved in clearing streets when it snows, involvement by multiple departments is required to effectively respond to flooding. Drawing upon the combined expertise of staff in the Fire, Parks and Recreation, Police, Public Works, and Water Services departments, as well as the NWS and COE, the plan would identify locations that have the potential for flooding, and responsibility for monitoring and blocking these locations would be assigned to city staff. Departments with assigned responsibilities would develop "stand-by" plans for use when potential exists for flash flooding. When warnings are issued, department staff should be prepared to provide immediate response. Meanwhile, Police and Fire department staff would be on the lookout for additional flooded locations. Once developed, the plan should be tested and revised as necessary to respond to future flood improvements and to include any knowledge gained during actual emergencies.

Public education is just as important as emergency response. The U.S. Army Corps of Engineers attributed many of the lives lost in the 1977 flood to carelessness or underestimation of danger. As a result, the COE emphasized the need for continuing public education about the dangers of flash flooding.[11]

---

[11] *Feasibility Report and Environmental Impact Statement: Brush Creek & Tributaries*, p. 12.

Public Education About The Dangers of Flash Floods

Public education about swiftwater takes many forms. It might be a news spot advising drivers not to go through flooded areas; brochures and flyers from organizations like the Red Cross and American Canoe Association explaining the dangers; an educational film like *No Way Out* detailing the dangers of flood channels; warning signs on hazardous areas; lectures by public safety officials in schools and churches; and "courtesy patrols" along the river during times of high water.

Prevention programs...tie in with the general mitigation effort. There are two kinds: *positive reinforcement* through educational programs, and *negative reinforcement* through law enforcement. The two complement each other; it is not enough for the American public to be told not to do something, they must be told *why* they should not do it.

Source: Slim Ray, *Swiftwater Rescue, A Manual for the Rescue Professional,* p. 189.

Residents knowledgeable about the nature of a flash flood and the appropriate safety precautions can take steps to protect their lives and properties. For example, a well-informed person is less likely to circumvent a barricade or drive into water. This is important because a car swept off an embankment into a river is one of the common causes of vehicle swiftwater accidents. Roughly 75 percent of these accidents happen at night or during periods of poor visibility, in part because of difficulty in judging the speed and depth of water in these conditions. Two feet of water will float most cars, but a car can be washed away in less, depending on such variables as speed of the current, design of the car, position of the car relative to the current.[12]

Elements of an Effective Flood Warning System

To learn how the city might improve its ability to respond to flash flooding, we interviewed experts in flash flood warning systems around the country. The experts identified the following elements of an effective flood warning system.

- **Identification of flood-prone areas.** An effective system monitors rainfall and water levels and uses scientific analysis to determine flood thresholds and detect flash floods. Services provided by the National Weather Service are included in the detection process.

[12] Slim Ray, *Swiftwater Rescue: A Manual for the Rescue Professional* (Asheville, NC: CFS Press, 1997), p. 169.

- **Formalized response by the local government.** An effective plan includes provisions for disseminating information on flash flooding including warnings to the public, and specifies when barriers will be erected at floodplain areas and by whom.

- **On-going public education.** An effective plan has a public education component. Local governments can use public education to prevent and minimize loss of life and property to flash floods by letting residents know what to do during these emergencies.

RECOMMENDATIONS

Our recommendations address the mayor's final question concerning improvements to the city's response during future flood emergencies. The following recommendations are addressed to the city manager:

1. Develop a comprehensive plan for implementing a flood warning system.

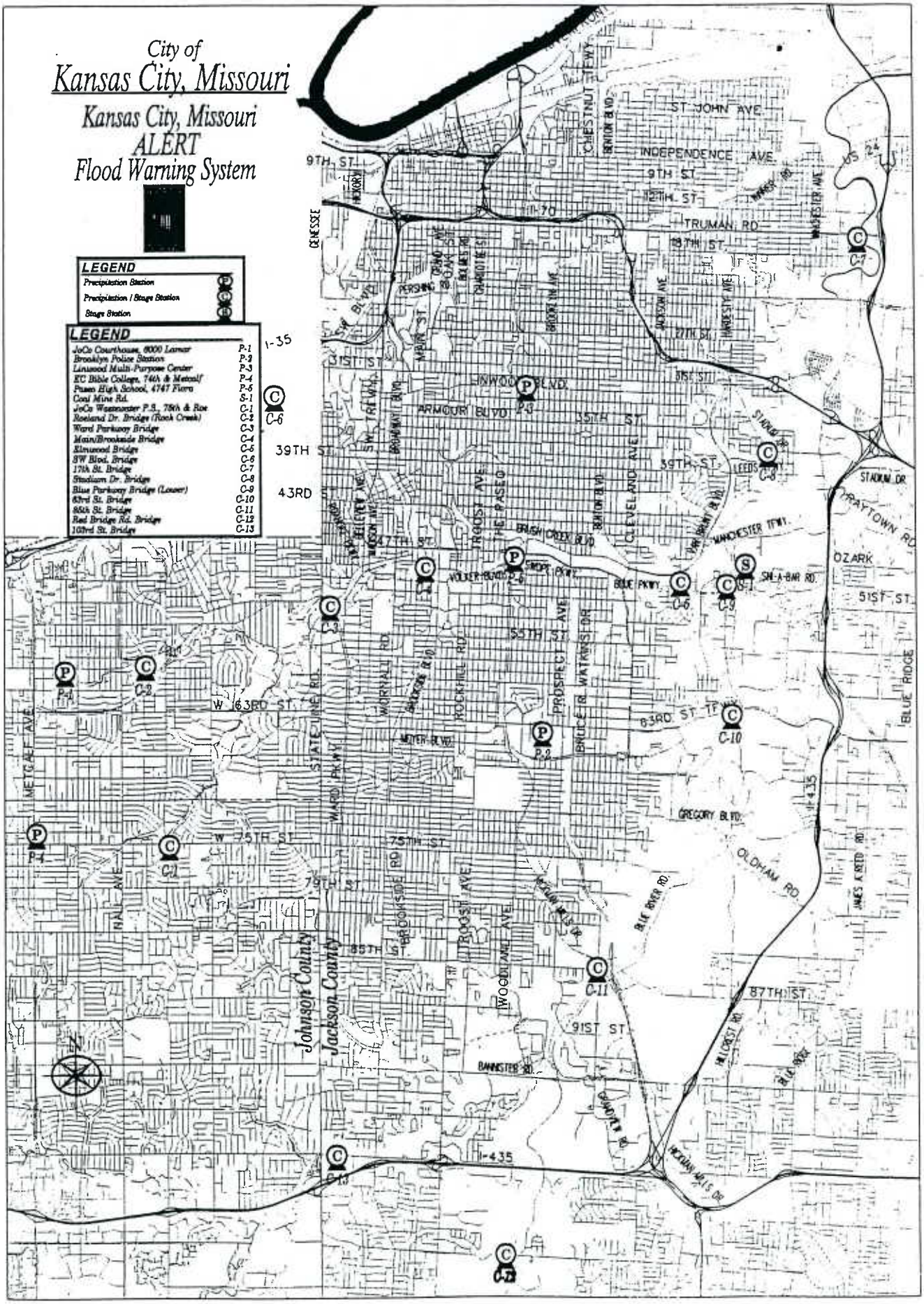
2. Complete negotiations and approve a Memorandum of Understanding with the National Weather Service.

3. Ensure that staff responsible for monitoring and maintaining the flood warning equipment are qualified to perform the work and interpret the results.

4. Move Emergency Preparedness from the Fire Department to the City Manager's Office.

5. Initiate a public education effort. Provide ongoing information to the public on the dangers related to flash flooding, the city's response efforts, and the precautions to take during flash flood watches and warnings.

Location of city's ALERT gauges.



Source: Water Services Department.